

§4. Fabrication of Erbium Oxide Coatings by Arc-Source Plasma Sputtering Device for Vanadium-Lithium Blanket System

Suzuki, A., Muroga, T.,
Maier, H., Koch, F. (IPP-Garching, EURATOM)

A self-cooled lithium / vanadium blanket is one of the most attractive concepts among blanket concepts for a commercial fusion reactor of high power density and less radioactive wastes. The primary issue associated with this blanket concept is potentially high magnetohydrodynamics (MHD) pressure drop induced by the liquid lithium flowing through high magnetic fields. In order to reduce the pressure drop to acceptable levels, fabrication of thin insulating coating (MHD coating) on inside surface of tubing has been proposed. The chemical compatibility of the insulating material with liquid Li is considered to be an important first step for developing the insulating coating. By former investigation on compatibility of bulk ceramics with liquid lithium [1], one of the best candidate oxide materials for the MHD coating is erbium oxide with crystalline, dense and low impurity. Plasma vapour deposition (PVD) method is a promising method to fabricate crystallized coating. In this report, we report results about the crystallization of Er_2O_3 thin films fabricated by one of the PVD method ; arc-source plasma deposition method.

With a filtered arc-source plasma deposition device, shown in Fig. 1, we deposit films with thicknesses up to several microns. A vacuum arc discharge on a solid erbium metal cathode produces erbium plasma, and together with oxygen added from a gas inlet an oxide ceramic coating is deposited onto the substrate. The arc discharge, however, also produces droplets of molten material, which would significantly reduce the performance of the MHD coating. A very effective method of avoiding this drawback is to prevent the droplets from reaching the substrate by a 90° toroidal magnetic filter. During the deposition, we can vary the substrate temperature as well as the substrate bias voltage. Heating of the samples up to 800°C is achieved by means of an infrared heater behind the substrate. RF-induced bias voltages can be applied up to -300 V, which transforms directly into kinetic energy of the particles impinging onto the growing film.

By Scanning Electron Microscopy (SEM), it was verified that the films had a very smooth structure with a complete coverage of the substrate surface. The stoichiometry of our metal oxide ceramic coatings was determined by means of Rutherford Backscattering (RBS) analysis. The film composition was evaluated using the program SIMNRA [2]. For the coatings we made at enough oxygen inlet, composition of the coatings is almost stoichiometric Er_2O_3 without a trace of impurities. The crystal structure analysis was performed using an X-ray diffraction (XRD) method with Cu-K_α . Typical results are shown in Fig. 2. The coatings fabricated at 570°C with a bias voltage of -100 V showed a XRD pattern of a cubic crystal structure of erbium. The solid vertical lines denote diffraction peaks of erbium oxide powder taken from a calculated ICDD powder

diffraction file [3]. From the fact that our measured spectrum displays all of the peaks calculated for a powder diffraction spectrum with mostly corresponding intensities it can be concluded that these coatings are polycrystalline without any specific texture. On the other hand, the coatings fabricated at room temperature showed with a bias voltage of -100 V showed a XRD pattern, which is not matched to the database of the powder diffraction files. XRD patterns obtained by grazing incidence measurement and θ -2 θ measurement show a different peak intensity with the same peak position to each other. These indicate that the coatings fabricated at room temperature are strongly textured. Thus, the phase of the coating made at room temperature could be a polycrystalline phase, which is different form one of the erbium powder made at high temperature.

References

[1] B. A. Pint et al., J. Nucl. Mater. 307 (2002) 1344.
[2] M. Mayer, Report IPP-Garching 9/113, 1997.
[3] ICDD powder diffraction file no. 77-0462.

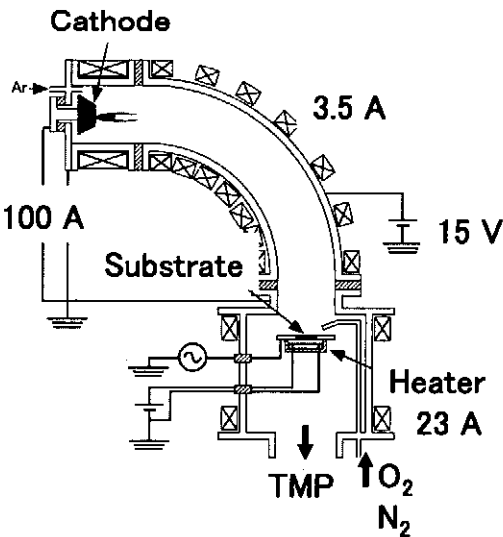
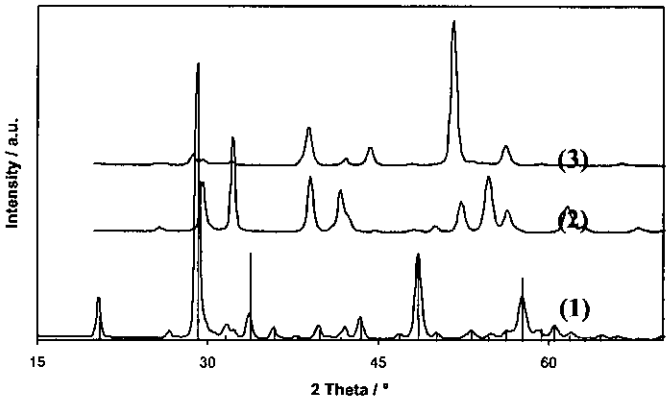


Fig. 1 apparatus of filtered arc-source plasma deposition device.



(1)Grazing incidence measurement of erbia film deposited at 570°C.
(2)Grazing incidence measurement of erbia film deposited at R.T.
(3) θ -2 θ measurement of the same film deposited at R.T.

Fig. 2 Typical XRD patterns of erbium oxide coating fabricated at low and high temperatures.